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FLIGHTS AND NEST STRUCTURE

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## THE SLAVE-MAKING ANT, *FORMICA SANGUINEA* *SUBINTEGRA* EMERY, ITS RAIDS, NUPTIAL FLIGHTS AND NEST STRUCTURE

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The sanguinary ants, or "blood-red slave makers," have long been of interest because of their conspicuous habit of making periodic forays to capture the young of other ants and transport them to their own nests. Here the young develop, thus forming mixed colonies of red and black workers which together carry on the activities of excavation and caring for the young.

Gibraltar Island, the site of the Franz Theodore Stone Laboratory of Ohio State University, makes an ideal unit for a habit study of the slave-making ant *Formica sanguinea subintegra* Emery, and of its slave ant *Formica fusca subsericea* Say. The island lies at the west end of Lake Erie and is cut off from its nearest neighboring land, South Bass Island, by a bay one-fourth of a mile wide. It consists of six acres of rock, covered with a thin layer of soil which supports a lawn and scattered trees, and has been maintained in this condition since 1865 when J. Cooke established a summer home there.

The island has undoubtedly long ago reached the maximum population of ants which it will support and probably there is a fairly constant balance between the number of *F. fusca subsericea* and *F. sanguinea subintegra* colonies since the *sanguineas* exist at the expense of the *fuscas*. If they should increase to such an extent that they wipe out the *fuscas* they themselves probably would not survive. The *fusca* colonies are often depleted by the continuous yearly raids of the slave-makers, yet there is a surprisingly large number of colonies which are never seen until the raiding *sanguineas* find them. The number of *sanguinea* nests present at any one time was never accurately determined. The problem was complicated by the tendency of the colonies to move from their own well-established nests into those of raided colonies. Several such moves might be

made during a summer so if a colony were lost track of and another discovered later, it could not be determined whether this was the original colony or a new one. However, there is good evidence from several years' observations that there are at least four large active *sanguinea* colonies on the island. There may be several more.

#### RAIDING ACTIVITIES

Raiding activities have been noted during the summers of 1930, '31, '33, '34, '35, '36 and '37, and in 1939 the information so gathered was rounded out by detailed study from the beginning of the raiding season until the end of August. Three large colonies were located for the observations. These, because of their locations, were named the Walk Nest, the Dock Nest and the North Nest. Daily observations were made on all three. However, the data gathered are almost entirely from the Walk and the Dock Nests since the North colony moved to an unknown location near the beginning of the raiding season and at the end of August had not returned. The nest was not entirely abandoned, for some blacks and a very few reds remained behind, keeping some entrance open.

*Records from Previous Years.*—It is known that the Dock Nest was in the present position in 1935, 1936 and 1937, and in these years it made raids to the dining hall, to Stone Memorial, and along the dock. The Walk Nest was found in its present location in 1930. On July 28, 1930, it moved to a new nest east of the caretaker's house, the workers carrying larvae, pupae, *fusca* workers, and *sanguinea* winged females. Raids were carried on from this new base. A nest found in 1931 near the lake by the caretaker's house may have been this same colony, and so may the one found in 1933 to the right of the fork of the Castle walk. The Walk Nest was discovered again in 1934 in its original position; a flight was witnessed from that site July 27, 1936, and it remained in place during 1937. No observations were made in 1938, but in 1939 it stayed in the original location all summer.

The North Nest seems to wander more. In 1930, a nest was found just north of the Trustees' Cottage. In 1931 there was one in the depression between the dining hall and the Trustees' Cottage. This raided a nest near the cottage (the site of the 1939 nest) and moved in there. Later that summer it moved to the north of the Trustees' Cottage. Still later in the season a nest, which was probably the same colony, was found between the Trustees' Cottage and Barney Cottage.

Other nests have been located: beside the laboratory steps ('30, '31), near the Castle ('34, '35, '36, '39), beside the Power House ('31), and at the east end of the island ('34, '39).

*Nest Construction and Location.*—There is no sign of any mound-building tendency on the part of any ant on Gibraltar Island. This may be partly influenced by the fact that the soil is shallow over the rocks in most places or that the grass has been kept mowed for many years.

McCook's observations that the *F. fusca subsericea* colonies which are constantly raided by *sanguineas* tend to conceal their openings, can be clearly verified by watching the Gibraltar colonies. Their nests are usually located in cut grass and from the surface show only a series of scattered openings with none of the excavated earth or cast off pupae cases which so often give the clue to nest location even when no mound is formed. The number of openings varies from two or three to as high as twenty scattered over an area five feet in diameter. Seemingly most of the colonies are small in comparison with the usual species size. There is a distinct and consistent tendency to plug some or all of the entrances with soil, pebbles, or grass. This is especially conspicuous just after nests have been raided.

The mixed *sanguinea-fusca* colonies show a markedly similar tendency toward inconspicuousness which indicates strongly that the slave members of the colony determine its mechanical structure.

The Walk Nest is located on a gently sloping lawn and extends on both sides of a cement walk. It is approximately one hundred inches long and seventy-five inches wide. Entrances are scattered irregularly, usually nine or ten above the walk and five or six below it. Their positions vary as new entrances are frequently opened and old ones plugged. There is no sign of debris at any time because of the workers' care in removing and depositing it beyond the confines of the nest. Individuals have been observed to go two feet from the nest to lay down an empty pupa case or bit of soil.

The Dock Nest extends along a ridge for one hundred thirty-five inches, the entrances all lying close along the curvature of the ridge top. Usually there are eight or nine openings, the number varying from time to time even more than at the Walk Nest. The greatest number are open during the days of flight. At no time are all the entrances used, for activity shifts from day to day from one group to another, depending on which is nearest the line of raid. After a rain, those caved in are promptly reopened.

*Typical Raiding Activities.*—On the morning of August 7, 1939, there was no sign of any activity about the Dock Nest. Single black ants were going back and forth foraging while a few reds were standing about. At about 3:30, a group of 14 started out rather slowly from the nest; these were followed soon by other clusters. Almost immediately some returned to the home nest so that soon the column consisted of ants going in both directions. It did not progress very rapidly for the first 15 minutes. Then there was a speeding up in progress because more ants went straight forward and fewer turned back so that an advance of 48 feet was made in the next half-hour. The line was a typical exploratory one, the ants forming a broad column about three feet wide and exploring every crack along this line. There was no constant front but the line simply faded into a few scattered individuals

# GIBRALTAR ISLAND Put-in-Bay, Ohio

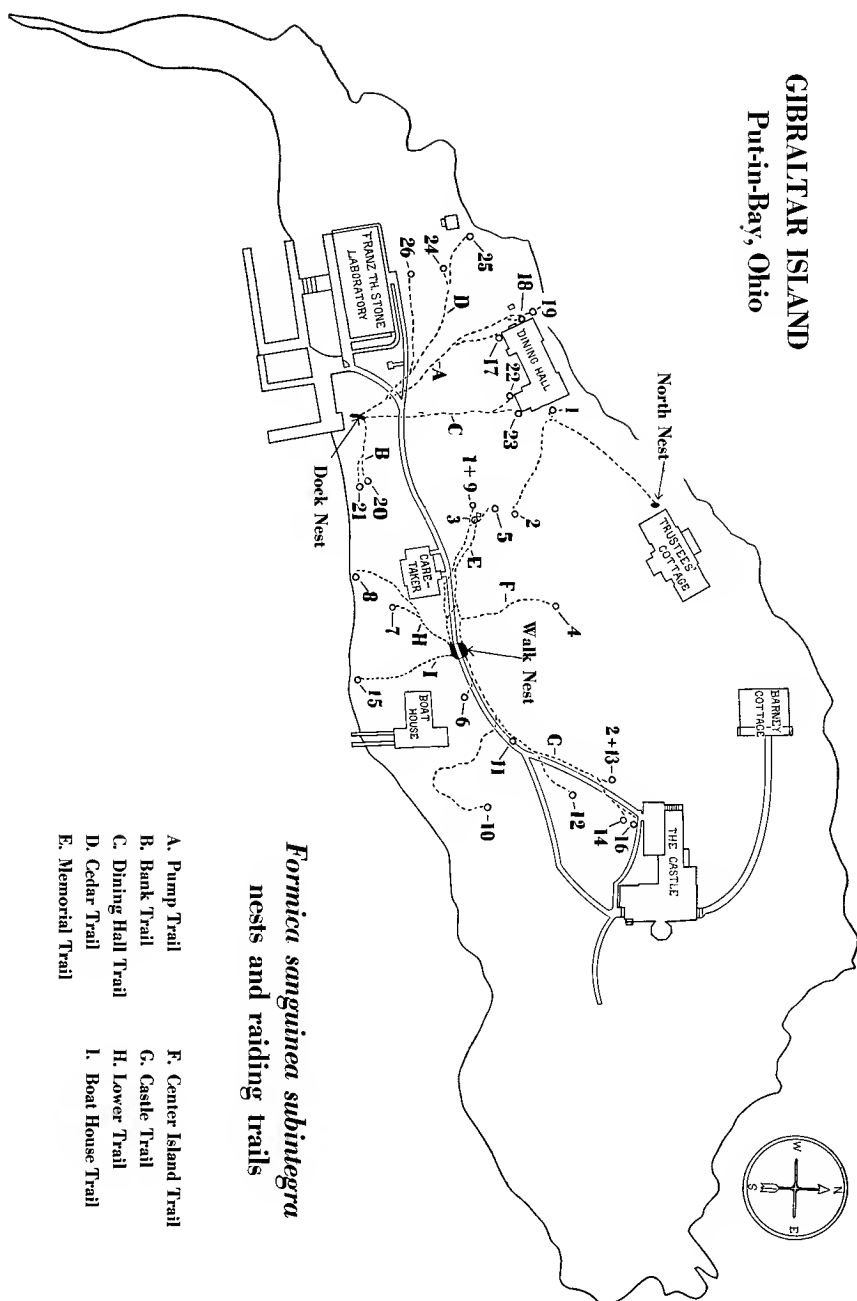


Fig. 1. Gibraltar Island, Put-in-Bay, Ohio, showing nests and raiding trails of *Formica sanguinea subintegra* and the nests (numbered) of its prey, *Formica fusca subsericea*.

making a fan-shaped end. There was no excitement and the ants moved slowly. By 5 o'clock the line had ceased to advance and more ants were returning to the nest than were going out. At 6:30 there was no trailing activity at all. That night there was a rain but the sun came out the next morning. At about 10:30, the exploratory groups started out again much as they had the afternoon before and followed the same course which the rain had not obliterated. They seemed to make no progress beyond the advance of the day before, and the line began to retreat about 11:30. By 1:30, the regular noon lull was observed and there was absolutely no activity at the nest. No further observation was made until 3:50, but at first glance it could be seen that something had happened. There were many more ants on the trail which was now but two feet wide, and they were traveling fast. The trail ended just before the dining hall in a great mass of ants gathered in a grassless area three feet in diameter which was scattered over with bits of burnt wood one-half to one inch long. Obviously a nest had been located, but it was a "plugged nest," that is a *fusca* nest whose openings had all been plugged shut by its own members. The *sanguineas* were exhibiting tremendous activity, exploring the area in minute detail and moving every bit of burnt wood encountered. At two places there was what seemed to be frenzied activity, with masses of reds tearing out bits of wood and exploring every crevice thus exposed. Evidently they were attacking two plugged entrances. Within ten minutes, one opening was penetrated and reds began disappearing in groups of 6 or 8. Immediately the first 4 black ants were routed out. Two of these walked quietly away, but the other two were pulled about a bit before being released. Within three minutes, there were streams of blacks pouring from both openings. Some were mauled but many were allowed to run away unmolested. Blacks continued to pour out for the next four minutes before a *sanguinea* appeared with the first pupa. From then on blacks, and reds with pupae, continued to leave the nest while other *sanguineas* found and unplugged more openings. A black queen which had emerged was halted once but dodged away into the grass. No individuals were killed, and those molested were invariably released uninjured. By 5:30, activity had slowed down considerably; a few blacks were still emerging and a few pupae were still being taken out by *sanguineas*. An interesting organization of *fusca* ants was occurring around the outskirts. Four black queens had by this time run out into the grass. A black worker was seen to drag one off and several other workers were carrying black workers who curled up beneath them. A group of 20-25 blacks was found gathered about a queen under a dead maple leaf and two other groups with queens were found under other bits of debris. Evidently black workers were actively gathering together into small groups all around the nest. By this time, many plugged entrances of the nest had been opened by the marauding reds and it could be seen that the raided nest was an enormous one, covering a diameter of five feet. There had been no evidence of this whatever at the beginning of the raid. Every entrance had been thoroughly plugged with the charred wood and no debris of any kind could be seen to indicate a nest. By 6:30 the line had almost

ceased, though red ants could be seen down in the galleries of the *fusca* nest. There was a rain in the night; however, it did not close the nest openings. At 7:30 the next morning everything was quiet at the raided nest. By 9:15 several reds, which had stayed overnight were seen at the main *fusca* opening and a few had just started toward the home nest with pupae. At about the same time a group of a dozen left the home nest and started along the old trail. Morning activities had begun at both ends of the line. By 9:20 pupae were being carried in a constant stream and an equal number of ants were traveling each way along the quiet, moderately-populated trail. This file lacked the numbers, compactness, speed, and excitement which marked the one just after the nest had been discovered. It also differed from the exploratory column in that it was narrower and the ants kept a steady pace, not moving off to the sides or stopping to investigate crannies. At 12:00 the noon lull occurred and the afternoon line did not begin again until 3:45. That afternoon almost no pupae were taken although the reds were still very much in possession of the captured nest, moving in and out of its galleries. Next morning (8-10-39) there was still a weak column connecting the *sanguinea* and the captured nests, but no pupae were being brought home.

When the line was visited at 3:15, it was obvious that exploratory maneuvers were again in progress. Numerous groups of ants were leaving the home nest in flurries, following the old trail to within four feet of the raided *fusca* nest where they swerved to the east and spread out into a typical broad exploratory formation four feet wide. Between 4:30 and 5:00, this broad front advanced six feet across the grass; by 5:50 the column was retreating without having found a nest. Next morning (8-11-39) activities were just beginning at 9:20 when typical groups of three to six ants were leaving the nest at intervals. The line was thin all morning and swung to the east of the previous day's exploration, and it dwindled to nothing by 11:55. No observations were made until 5:20 when it was found that the *sanguineas* had again located a nest not far from the other. Once again activities were at their height; blacks were pouring out and *sanguineas* were carrying off pupae.

The raiding of these nests has been given in detail because it is typical of the activities which went on day after day at the Dock Nest and at Skipper's Nest. Activities on the trail varied according to whether the ants were exploring, had just discovered a nest to loot, or were carrying on routine plundering. Length of noon lulls and duration of raids into the evening depended on the activities in progress. Unsuccessful raids tended to stop earlier. Most *fusca* nests were found to be thoroughly concealed by twigs, stones, or grass, and had to be unplugged before the reds could enter. This was the period of the greatest massing of ants, the most thickly populated columns, and the greatest seeming excitement. Once the reds could descend into the nest galleries blacks came pouring out with little evidence of resistance. Some were dragged out by legs, antennae, or mandibles by red workers and then were released; many more simply walked off. Some were mauled by one, two or three reds pulling at them; but they were usually

released and allowed to escape uninjured. These blacks rounded up their fellow workers and queens and reentered their nests just as soon as the reds deserted them, whether this was the next day or several days later. A few ants would carry their fellows back in the typical manner of transportation, with the transported ant curled up beneath the carrier. The nest openings were again plugged so thoroughly that often they could not be detected even though their locations had been marked previously.

*Sanguineas* took complete possession of the raided nests and individuals remained overnight there until the raiding was over. It was found that some blacks also stayed in the nest in seeming peacefulness. These could not be blacks of the mixed *sanguinea-fusca* home nest, for they were never seen to take part in a raid.

*Trails.*—Each *sanguinea* colony had certain definite well-established trails which exploring parties followed as far as possible before deviating off in search of a new colony. These trails were not, as is the case with *Camponotus*, visible pathways, but they seemed to be a habit of procedure. Probably odor played a part in their maintenance, but there was no slavish following of a line as is found in *Crematogaster*, nor did rain in any way weaken the trail. The map shows the main trails which were traversed day after day until the investigator could pick up the line at a given point and know just how the ants had come to that place from the home nest: for, example, the Pump trail of the Dock Nest always crossed the sidewalks just before they joined. (See map.) It was only after Nest No. 9 had been discovered late in the summer that the trail was shifted so that it crossed the walk to the west of the previous crossing. In a similar fashion, the Castle trail of the Walk Nest could always be picked up just to the north of the walk leading to the Castle. The way in which deviations occurred from these trails is rather interesting. After Nest No. 22 had been raided by the Dock Nest, an exploring party started out east from it and discovered No. 23. Next day the line swerved to the east before it reached No. 22 and all loot brought in from No. 23 followed this new branch which then straightened the trail and shortened the distance traveled to the home nest. Other such instances of straightening the trail were found during the summer.

When some ants from the Walk Nest located Nest No. 10, a strong line was already exploring along the Castle trail. At 11:45 a great disturbance was noticed on the side walk where the branching to No. 10 occurred. Reds were mauling fellow reds, and it seemed as if there were difficulty in getting the line of march to turn to the right toward No. 10. By 12:30 enough ants had been deflected to the new trail branch to bring back a line of pupae from No. 10, but the main Castle trail had not been abandoned. At 5:15 the Castle column suddenly uncovered Nest No. 11, which surprisingly enough lay beneath the regular trail which had been traversed for weeks. Evidently it had been well plugged. At 5:38 the first pupae were brought out, and now ants were carrying pupae from two nests (Nos. 10 and 11). The ants of the remaining Castle trail, still exploring in the grass beyond, had meantime located Nest No. 12; and by 5:45 they were bringing pupae



TRAILS		WALK NEST					DOCK NEST			
		Me- morial	Castle	Center Island	Lower	Boat House	Pump	Bank	Dining Hall	Cedar
8- 1-'39.....	A. M.	E		P			P			
	P. M.	No. 5					E			
8- 2-'39.....	A. M.		No. 6	E				E		
	P. M.		E					No. 20		
8- 3-'39.....	A. M.	E						E		
	P. M.				No. 7			No. 21		
8- 4-'39.....	A. M.				E					
	P. M.							E		
8- 5-'35.....	A. M.							E		
	P. M.							E		
8- 6-'35.....	A. M.	E			No. 8					
	P. M.	E			P					
8- 7-'39.....	A. M.	No. 9			P					
	P. M.				E				E	
8- 8-'39.....	A. M.	E			E				E	
	P. M.	E	E		E				No. 22	
8- 9-'39.....	A. M.	E							P	
	P. M.	E	E			E			P	
8-10-'39.....	A. M.	E	No. 10		E				P	
	P. M.		No. 11 No. 12						E	
8-11-'39.....	A. M.		P						E	
	P. M.		No. 13 No. 14						No. 23	
8-12-'39.....	A. M.		P			E			P	
	P. M.		P			No. 15			E	
8-13-'39.....	A. M.		E			P			E	
	P. M.		No. 16					E		
8-14-'38.....	A. M.		P			E		E		
	P. M.		P							
8-15-'39.....	A. M.		P							
	P. M.		P				E			
8-16-'39.....	A. M.		P				E			
	P. M.		P							No. 24
8-17-'39.....	A. M.		P							E
	P. M.		P							No. 25
8-18-'39.....	A. M.		P							P
	P. M.		E							E

An eighteen day record at the twice dialy forays of two *Formica sanguinea subintegra* colonies.

Numbers 5-25 indicate *Formica fusca subserica* nests raided (see map). Each nest raided implies a successful exploratory foray plus a period of plundering.

P=Continued plundering of a nest after the initial entrance and looting.

E=Exploratory forays which did not succeed in locating nests.

from it. Thus in one day three nests were discovered and by late afternoon pupae were being brought from all three over the Castle trail. As might have been predicted, after such a successful day, ants were still on the trail at 7:45 in the dusk and chill of the evening.

These permanent trails were not tried out and abandoned successively but were returned to, time after time, throughout the season as can be seen by the chart which shows daily records for part of the summer.

*Numbers of Ants on the Trail.*—The number of ants on a trail at any one time varies tremendously, as does also the proportion of those leaving the home nest and those returning to it. A set of counts made on a Dock Nest trail may be considered typical. At 3:30 the afternoon raid was just beginning along an old trail and was densely populated with a steady stream of ants. The line was narrow, 6 or 8 inches wide, and was progressing about 14 feet in 5 minutes. In half an hour the column had progressed and spread out into the typical exploratory one four feet wide, with a fan-shaped end over eight feet in width. Thirty-five minutes after the raid began, many ants in the front were starting to return to the home nest; evidently a nest that might be raided had been located, and individuals were returning apparently for reinforcements. At this time only 61 ants were going out while 133 returned to the home nest during a five-minute period. Forty-five minutes after the retreat began the direction of flow had changed once again and many more ants were going out than back. The line had now ended beneath a cedar tree where the raiding ants were exploring all crevices. Within an hour, pupae were being carried from the nest discovered beneath this cedar, and by 6 P. M., no more ants were coming from the home nest, but a steady stream were returning to it. At this time, in 5 minutes, 163 crossed the line, 20 of which carried pupae. At 6:40, in 5 minutes, only 105 ants returned home, 3 carrying pupae; however, this still made a fairly good column, a steady stream of ants moving rather slowly.

At no time did all the ants returning home carry loot. A strong line, at the height of looting activity, was checked for number. The column was narrow (7 inches across) with little obstruction, so that ants were moving steadily and rapidly. In 15 minutes, 376 ants were counted going toward the nest being raided, while 392 ants were counted returning home from it. Of those returning 136 were carrying pupae, 26 had larvae, and one black adult was being transported. Thus fewer than 42% of the returning ants were carrying brood.

The speed of individual ants carrying pupae was recorded for intervals of one minute. This varied from 24 to 36 inches traveled per minute. The distance traversed depended largely on whether the individual found a bit of bare ground or whether it had to manipulate the pupa through impeding grass stems. The ants did not follow a rigid path, but each picked its own course within the width of a foot.

*Nests Raided.*—The numbers of nests raided were few in comparison with the numbers of forays made. In 1939, between July 14 and August 20, the Walk Nest made 42 observed forays and raided 16 nests. The Dock Nest, in this period, made 36 observed forays and raided 10 nests. Distances traveled to these nests varied considerably, the

farthest being 210 feet, while others were 165, 130, 76, and 40 feet. There was no indication of "territory" in which each *sanguinea* colony was privileged to loot, except in so far as the nests were of sufficient distance apart so that their lines of raid never crossed each other. Occupation of a raided nest did not usually extend over many days. From 24 records it was found that occupation of a nest lasted only one day in 8 cases, and extended over 2 days in 12 cases; in the other four raids occupation lasted 3, 4, 6, and 7 days, respectively.

*Duration of Raiding Periods.*—At Gibraltar Island, the *sanguinea* raiding season begins in July, the earliest one observed being that of July 7, 1933. Since the raids are very conspicuous on the island and are looked for each year the first observed raid is probably the first actual raid, or within a few days of it. Records of first observed raids are as follows: 7-21-29, 7-20-30, 7-15-31, 7-7-33, 7-29-34, 7-17-35, 7-21-37, 7-14-39. In some cases nests were known and watched a number of days before the beginning of the raiding season. From these observations, it has been found that there is very little surface activity during this early summer period. *Fuscas* come in and out foraging, and occasionally a *sanguinea* comes up to deposit an empty cocoon, for this is the time of the maturing of the winged forms; otherwise there is nothing to draw attention to the nest.

We have no records for the end of the raiding season. The latest observed forays were 8-27-37 and 8-20-39. Records ended here because the observers left the island, not because raiding activities had ceased. In fact, they had not even slowed down. It seems probable that the season lasts on into September, thus extending the raiding activities through a month and a half or two months.

Once raiding begins it continues daily, one raid each morning and one each afternoon, unless interrupted by rain. In 1939 there were two unexplained periods of suppressed activity (see chart) which affected both the Walk and the Dock Nest to varying degrees, but aside from these depressions and periods of rain, two forays left each nest every day. The noon lull was regular regardless of the weather. The length of time of morning or afternoon raiding activities varied considerably. If an exploratory foray was unsuccessful, activities ceased early, while if a new nest was discovered late in the afternoon the ants continued to transport loot until dark. If dark overtook pillaging ants in the captured nest, they remained there overnight and began their return journey early next morning. The morning line usually began between 9 and 10 o'clock, but it might commence as early as 7:15 or as late as 10:45. The morning raid was usually over by 12:30 or 12:40, but has been known to stop by 11:00 when unsuccessful, or to continue until 2:00 when pupae were being brought in. Afternoon raids varied a great deal in their beginning but usually started between 2:30 and 3:30. Ordinarily activity ceased by 7:00 or 7:15, but after a vigorous and successful raid, ants have been found on the trail in the dusk of the evening (7:45-8:00).

*Effect of Temperature.*—Raiding activities are not directly dependent upon temperature, as can be shown by a comparison of the two nests. Degrees of activity never correspond between the two; a strong raid

from one was often paralleled by a weak raid from the other. In a similar fashion one nest might start early in the morning or work late at night, while the other showed only scant, dilatory action. One interesting instance of "heat trap" occurred at the Walk Nest. On August 13, workers coming in from the Castle trail at 11:30 seemed to "go crazy" as they emerged from the shaded trail into the full sun of the nest area. Movements became fast and jerky; individuals climbed to the top of grass blades, then down and up others, thus avoiding the ground. They were running at random, carrying larvae, pupae, and black or red workers indiscriminately, and they did not seem to be able to get down to the nest openings. At noon the next day, the same peculiar process was repeated. This time, temperature readings were taken. The soil surface of the nest in the sun was 45° C.; one inch above the soil at the grass blade level, the temperature was 38° C.; in the shade near by, the soil surface was only 31° C. The ants on the trail were behaving normally in a perfectly normal temperature, but the soil of the sunny nest area had reached a temperature above their usual toleration, forcing them up onto the grass blades. Each time they came down to the ground to enter the nest they were forced up again away from the excess heat, until the whole area became covered with the returning ants unable to descend into the nest. However, within an hour most of the ants did succeed in penetrating the openings and the noon lull occurred as usual.

#### NUPTIAL FLIGHTS

The emergence of *sanguinea* males and females occurs near the beginning of the raiding season. The only series of flights which were accurately observed and recorded on Gibraltar were those of 1939. They showed quite clearly that flight does not occur in one splendid climax of masses rising into the air but may drag out over a number of days. The first flight was observed July 19, 1939, at 9:15 A. M., by C. H. Kennedy. This emergence at the Walk Nest was discovered when the first raiding trail of the year was traced back to the home nest. The morning had been clear and bright at 8 A. M., but by 9:15 a haze had covered the entire sky and a dead calm existed. The air was pleasantly warm. Activity was at its height when the nest was discovered. Numerous winged females were darting about on the ground or standing in clusters of two to five, at nest entrances or under bits of cover. By 9:30 some females were attempting to fly. They would climb grass blades, poise for a moment, then suddenly spread wings and take off. Some flew 150 feet at two to six feet above the ground before being lost to sight. Others rose almost straight up to the tree tops. Apparently the flight was at random, merely a dispersion out into the air. Almost all the winged ants leaving the nest were female; only four males were seen. During the activity many workers were present at nest openings and over the whole area of flight. By 9:40 the seemingly excited *sanguinea* and *fusca* workers were beginning to drag females back into the nest; by 10:00 the flight had decidedly slowed down and, by 10:15, it was practically over for the day, workers as well as winged females having gone back underground.

While this female flight was going on at the Walk Nest, a male flight was occurring at the Dock Nest. Here not as many individuals succeeded in flying, most of the male activity consisting in darting out one opening and back into another. Workers were numerous about the holes and seemed partly successful in preventing the males from leaving the nest.

The second day flight was checked more closely for its beginning and duration. The Dock Nest was active at 7 A. M., at which time males were seen clustered about the entrances. By 7:30 they were crawling up grass stems and flying away, while by 8:30 the flight was over. The Walk Nest was a little slower in getting started. Only a few workers were out at 8:30. The female flight was well under way by 9 and had quieted down by 10. A slight difference in activity was observed on the shady and sunny sides of the nest. The females emerging into full sunlight rushed directly up grass blades and flew immediately. Those in the shaded area loitered before flying and many were found secreted under dead grass clippings on the ground.

On the third day (7-21-39) the flights proceeded in the usual manner. At 7 A. M. the males of the Dock Nest were appearing at the openings, by 7:30 they were flying, and by 8:30 flight was over. At the Walk Nest the females did not begin to fly until 8:30 and a few were still emerging by 11 A. M.

Nests were not observed the next day but on July 23 the Walk Nest was found to be raiding, with no further signs of flight then or later. On July 24 a dilatory flight of males and a few females occurred at the Dock Nest and on July 27 a few winged females were seen to leave its entrances. Thus the flights dragged to a close.

Twice within the next week dealate females were seen near the large nests. In both cases workers were massed about them pulling them in all directions. They also seemed to be licking them. When the females were freed they were found to be unhurt, but evidently they were not allowed to re-enter the parent nest once they had left it.

A flight observed July 6, 1936, and numerous records of the occurrence of winged forms in the nests indicate that flight time has varied from about July 6 to August 3. It is interesting in this connection to find A. C. Burrill's record of a *sanguinea* flight which occurred at 9:30 A. M., August 6, 1900, at North Brookfield, Mass.

The tendency toward a "male" colony or a "female" colony is quite common in other species of ants as well as in the *sanguinea*. In the Gibraltar colonies it was noted that the female nest produced a few males and that a few females emerged from the male nest on each day of its flight. It would be interesting to understand the mechanism behind this.

#### NEST STRUCTURE

Talbot and Kennedy dug one nest (No. 2136 on South Bass Island) to the bottom and Kennedy has dug three other nests. As *sanguinea subintegra* seizes and occupies *fusca subsericea* nests and has the help of these black slaves in enlarging nests, the *sanguinea subintegra* nest probably follows the forms of *fusca* architecture. The authors have

made no close study of *fusca* nests but numerous field notes on *fusca* show similar nests except that *fusca* nests nearly always have more elaborate top galleries, as in our figure 2, than do *sanguinea* nests. We have found three types of nests: (1) Nests in crevices of massive rock; (2) Nests in flat surfaced clay soil; (3) Nests in *fusca* mounds. The only type of *fusca* nest not represented is the occasional one in a well rotted stump or log, a type which is scarce even in wooded areas.

1. Nests in crevices of massive rock are the common type on Gibraltar Island. The first attempt to dig a *sanguinea* nest was made on one near figure 18 on the map. At ten inches deep the leading gallery passed down between two great blocks of stone that could not have been easily moved. After this disturbance the colony disappeared.

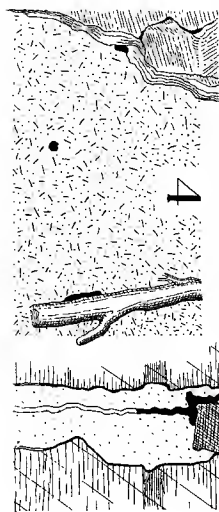
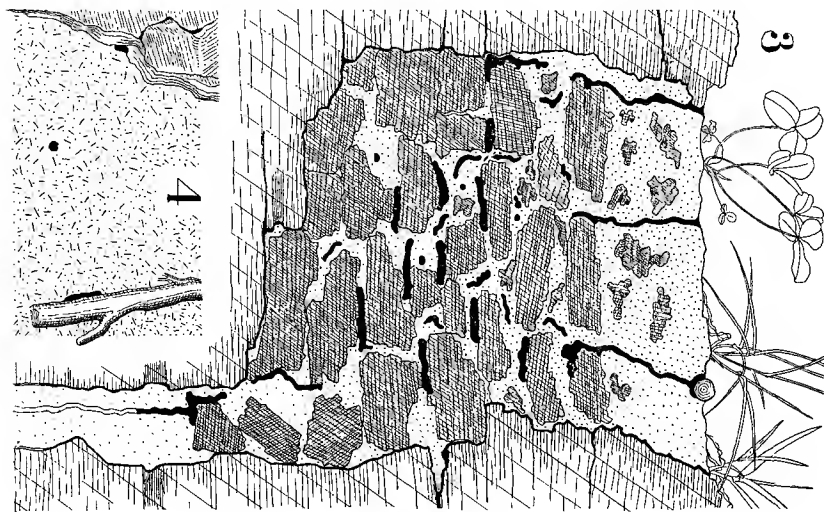
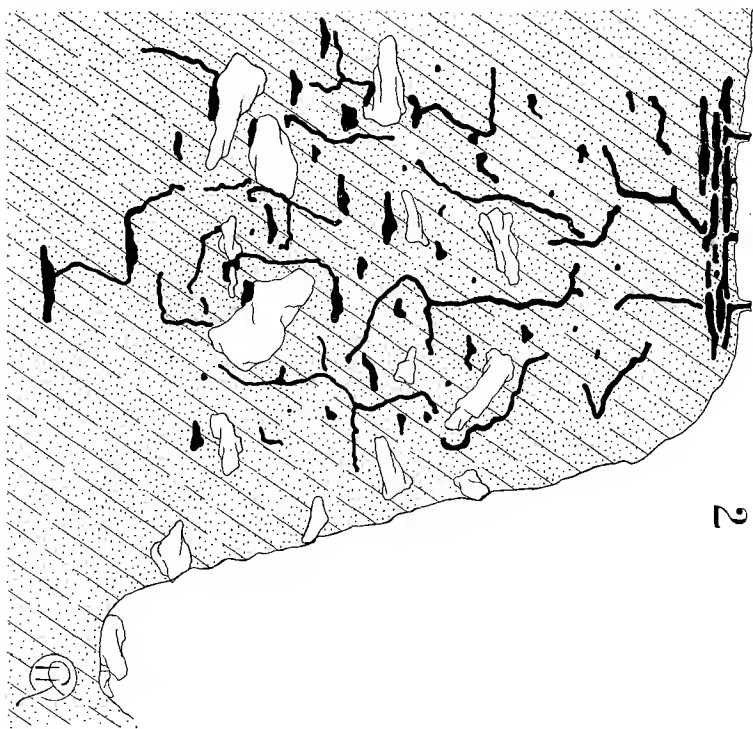
The second attempt was on a nest (Kennedy Coll., No. 1236 taken July 8, 1933) that would lie on our map between "No. 10" and the walk north of it. Dr. Norris D. Blackburn assisted in the excavation. A diagrammatic section of this nest is shown in figure 3, its three openings in figure 4. The longest opening was under the side of the surface root of a *Celtis* tree that shaded the area. The gallery leading down from it was 0.75 inch in diameter. The middle opening was 2.5 inches in diameter, that next the rock, 1 inch. The surrounding plants were largely blue grass. The nest was in the cleft between two outcrops of limestone. This cleft, about eighteen inches wide, was filled with the black soil of the island and numerous closely packed chunks of the native limestone. The top two or three inches were soil, then down to solid rock at 2 to 2½ feet, the filling was composed of soil with more than fifty per cent of its volume made of limestone chunks, one inch to one foot in diameter. There were no surface galleries (as in fig. 2). The three galleries led down eight to ten inches where the first chambers were found. Fifteen to twenty chambers were found from this level to a depth of over two feet. The greatest number were in a zone between the depths of twelve and eighteen inches. Chambers varied from 1 to 4 inches in length, 1 to 1.5 inches wide and were usually about 0.75 inch high. The position was generally just under the edge of a stone. However, the larger stones did not have nests under their central areas. The lowest chamber had a gallery that led straight down from it into the narrowed cleft between the limestone rocks.

This proved to be a queen nest. The many winged queens, of which one-third were callows, were found scattered variously in chambers at all levels. Only three males were found. There were few pupae. Ten black slaves occurred for each *sanguinea* worker. The red workers were much more solicitous in caring for the brood than were the black workers.

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#### EXPLANATION OF PLATE II.

Figs. 2-4. *Formica sanguinea subintegra* nests. 2. Diagrammatic section of nest (type in deep well drained soil) collected on Toll Hill, Adams County, Ohio. This shows the unusual chimney-like nest openings, and the subsurface or top galleries common to *fusca* and many other ant nests. 3. A nest of the type in a broad cleft of massive limestone, collected by Blackburn and Kennedy on Gibraltar Island. 4. The openings of nest shown in fig. 3.



Our figure 7 shows a map of the Walk Nest of figure 1. It shows the short paths which lead for a foot or two from the larger openings. These paths escape notice easily as they are generally arched over by grass. During 1939 there was *never any debris* about this nest. Even pupal cases were carried out far beyond the edge of the nest and were scattered. In figure 7 the areas about the nest openings free of debris are shown stippled.

2. The first nest taken in deep soil was discovered by Professor A. C. Cole and Kennedy, April 17, 1931, on the bank of a road running up the side of Toll Hill, southeast of Peebles, Adams Co., Ohio. On the edge of this bare, three-feet-high clay bank the top of the nest covered an area two by five feet. This area was a low clay mound averaging 4 inches high and bare except for an occasional spray of grass. Scattered over it were a dozen or so of the usual funnel openings and among them were a few clay "chimneys" two inches tall (fig. 2). It was the only nest Kennedy has ever seen with chimned openings. Except for the chimneys, this low, clay-dome type of nest surface is characteristic of *Formica fusca subsericea* nests in the hills of southern Ohio. Such structure occurs on those well defined slopes where the water-table does not approach the surface by a vertical distance of many feet. This low dome-type of *subsericea* nest has been observed by Professor C. A. Dennis and Kennedy in the hills of Tennessee. We have seen such bare clay areas ten feet in diameter though two or three feet is the usual size.

The first one to two inches was irregularly chambered but the next six inches was a mass of interlocked flat brood (?) chambers (fig. 2). Below this, level galleries ran downward in all directions connecting here and there with irregular chambers below. In the top foot of the side of the nest there were ten *fusca* workers to each *sanguinea* worker. The nest was then recovered to be opened at some later date in the hope of collecting winged forms.

On August 5, 1932, Professor C. A. Dennis and Kennedy dug this Adams County nest to below its last bottom chamber. The bottom cell was 36 inches below the top surface. Our notes indicate the first four inches were with flat interlocked chambers in which were a few *fusca* workers. No mention is made of the curious clay chimneys found in April of the preceding year on this same nest. Next below the surface brood chamber irregular galleries ran down to about 24 inches, these averaging six inches apart and wandering in all directions. They varied in diameter from that large enough to pass one ant, to those the size of a lead pencil. Chambers one to two inches in diameter

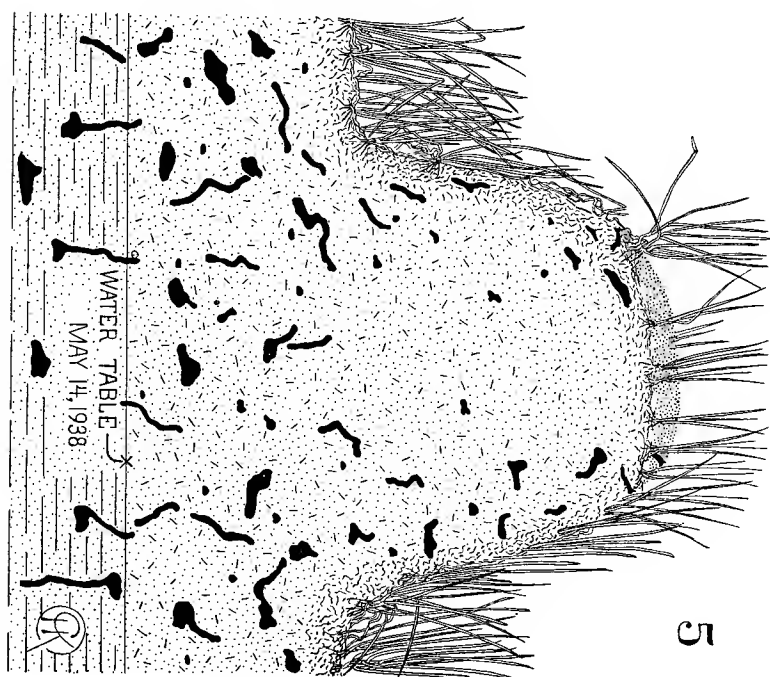
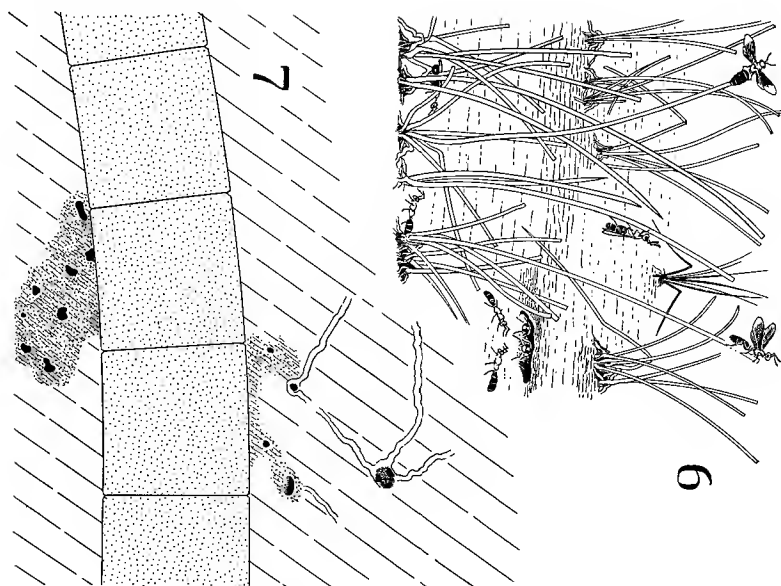
#### EXPLANATION OF PLATE III.

Fig. 5. *Formica sanguinea subintegra* nest in a *Formica fusca subsericea* mound on the Bronson farm, Kipton, Ohio. A mound associated with a high water table.

Fig. 6. Diagrammatic sketch showing the meager nature of flight activities in a *sanguinea* colony, in this case a queen producing nest.

Fig. 7. Sketch map of surface openings of the "Walk Nest" on Gibraltar Island. Stipple indicates areas free of debris. Short paths are shown by parallel lines radiating from the blackened nest openings.





were most numerous in the area between 24 and 30 inches down, at which level chambers occurred 2 to 6 inches apart.

The nest queen was found at the 24 inch level. There was much worker brood (larvae and pupae) but no winged forms. There were about ten black slaves to each red slavemaker. A nest (No. 907) of a species of red *Aphenogaster* was found in some loose leaves on the top of the *sanguinea* nest.

The second nest of this type in normal deep clay was dug by Talbot and Kennedy, July 27, 1935. It was located on South Bass Island in one of the strips of open glade in the woods. At the surface a bare place in the blue grass three feet in diameter gave evidence of the nest. There was one active entrance which was on one side of the bare area. On digging, it was found that the nest extended down 27 inches and was wider than the bare area of ground above. Near the surface cross galleries were common but lower down galleries were usually vertical. Ants were packed tightly into many chambers and in galleries. With the workers were larvae, naked and covered pupae, many males and a few winged females. The temperature down two feet in the moist clay was 70° F. while at the surface it was 98° F.

3. Nests in mounds were found four times by Kennedy. (Nos. 2945 and 2947, Kennedy Coll., along roadside east of Westerville, Ohio, 2950, on the Fril Bronson farm one mile south of Camden Center, Lorain Co., Ohio, and an unrecorded nest on a game refuge south of Camden Center.) In each case the *sanguinea* mound was associated with mounds of *fusca subsericea*. In each case the mounds were in flat country where the water table came to the surface during the wet season (winter and early spring) and where the mound appeared to be a necessity to keep from drowning.

Our figure 5 is a diagram of the *sanguinea subintegra* nest on the Bronson farm. This was dug May 14, 1939, by Kennedy and his son Bruce. This bluegrass-covered mound was one of 70 similar mounds located along the west edge of an oak-hickory woods in the perfectly flat old lake bed of the Camden Center area. The 70 *fusca subsericea* mounds were each opened and inspected enough to be fairly certain that no red ants were present. It was the only *sanguinea* mound found. The nest was dug to one foot below the surface when free water was encountered though the ant galleries plunged vertically into this drowned area. We dug out chunks of clay six inches below the surface of the water but found no drowned or live ants in the submerged chambers. There were few chambers in the center of the mound. The greater number were between the surface of the ground and the water table. These lower chambers spread beyond the perimeter of the mound above. In the south wall of the nest-mound a considerable nest of *Crematogaster* occurred.

The colony was large with ten black slaves to one red worker. In some of the lower chambers were clutches of eggs. No larvae or pupae were found. No drowned or dead ants were found. Thus, as no larvae were found at this early date we can infer that the many workers present were from the 1938 season. We can infer further that in some manner the hibernating ants were able to escape drowning by the rising water table. They must have gone into hibernation the fall before when the water table was much lower.

The lower chambers were slippery wet yet this condition did not appear to bother the red and the black workers.

We can state some general features of *sanguinea* nests. The nests dug to what was believed to be the bottom were from two and a half to three feet deep. The chambers were irregular in shape and varied up to four inches in length, with a width of 1 to 1.5 inches and a height of 0.75 inch. The area of greatest number of cells is at middepth of the nest. They follow the local architecture of the slave species, *fusca subsericea*, in that in such territory as Gibraltar Island where drainage is perfect no mound is made and no top brood chambers are constructed. The ground is unusually dry and warm enough that the brood is reared in deep chambers. In flat, wet, undrained country, as in the glacial lake bed about Camden Center, they make use of mounds as does their prey, *fusca subsericea*.

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